

OCCLUDING PULMONARY EMBOLISM.

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CONSIDERING the fact that it was not until the first quarter of the seventeenth century that the circulation of the blood was established it is not surprising that over two hundred years more should have elapsed before it occurred to any one that this flowing stream could act as a means of transportation for solid particles set free in its current, and that such particles introduced into the blood might be found in some place other than the point of entry.

So simple is the mechanism of thrombosis and embolism as it is taught to-day that we wonder why it was necessary for Virchow to establish the self-evident fact that injury to a vessel or changes in the blood sufficient to cause clotting at some particular point might be followed by dislodgement of a piece of this solid clot and that this broken off mass would be carried on by the blood stream until it reached a vessel too small for it to pass through and then stop. It is also plain that the blocking of a vessel by this solid mass would stop the circulation through this vessel and give rise to disturbances of great importance or of little importance depending on whether or not this vessel supplied an organ, the function of which was necessary to maintain life.

In this paper we desire to discuss especially the instances in which venous thrombosis, in either medical or surgical cases, is followed by emboli of sufficient size or number to block completely the more important branches or the main stem of the pulmonary artery and cause sudden death.

These cases, which we are to discuss, of complete blocking of the pulmonary artery by large masses of clot derived from a thrombus in a vein, which are frequently encountered by the surgeon near the operative area and which may result in death are by no means uncommon. They occur most frequently between the second and fourth weeks following the operation. The patient may die instantaneously or there may be a more or less prolonged respiratory struggle ending in death. This depends on whether the detached mass goes through the right heart intact in sufficient size to completely block the stem of the pulmonary artery or whether the first mass partially blocks the artery, or blocks one of its main divisions, and is followed by other masses, or coagulation of blood behind the first. If the trunk of the pulmonary artery is blocked so that both the main branches are closed death ensues immediately. In individuals suffering from weakened heart action of any cause sudden blocking of one of the main branches of the pulmonary artery may also result in sudden death. Strong heart action on the contrary may overcome the effect of the blocking of one of the main branches of this artery and the patient survive.

The autopsy findings in these cases so far as the lungs are concerned are scant. Occlusion of the trunk of the pulmonary artery does not give rise to infarction of the lungs. Infarction of the lung is only present when emboli have lodged in the smaller branches of the pulmonary artery. Cases are seen in which small emboli have preceded the final lethal embolus and caused hemorrhagic infarction of the lung, but these infarctions have no immediate part in causing death in such an instance. Only rarely are they found in connection with the type of pulmonary embolism with which we are dealing and then usually when there is thrombosis of several veins at the operative site. Any of these thrombi may give rise to emboli and a small embolus might have been carried to the lung at any time from one of these thrombi wholly independent of the embolus that caused death.

In autopsies on cases of death from pulmonary embolism

the pulmonary artery should always be opened *in situ* before the heart is removed or cut into, as the site of the embolus is usually at the point where the vessels are cut in removal of the heart. If this is not done, the embolus, which may have had no time for attachment, can easily slip out unobserved and be entirely overlooked by the pathologist.

The origin of the embolus, while it might come from any part of the systemic venous system or the right heart, is most frequently found in the veins of the lower extremities; in the deep epigastric and pelvic veins; or in the mesenteric veins. In our medical cases the thrombus was found the most times in the right heart.

Albanus gives as prevailing causes for thrombosis after laparotomies, sepsis, heart imperfections, pressure of tumors on veins; cooling and handling of blood vessels while the abdomen is open; the effect of narcosis on the heart; the recumbent position and the pressure of a bandage. He overlooks what we believe to be a most fruitful cause of the condition, varicosities on veins which are directly affected by the operation. On the operating table it is not uncommon to see greatly changed veins carrying the blood from large tumors and in one instance at least, No. 2 of our series, we were able to demonstrate both at operation and autopsy these varicose veins and their causal relation to fatal embolism.

All lung symptoms, according to Gussenbauer, which arise after the release of incarcerated hernia are to be regarded as embolic in nature. Other surgeons go equally far in connecting this subject with abdominal surgery. It is the practice of the Mayos when resecting the stomach to invariably cauterize the cut edges of that viscus to prevent septic pulmonary embolism. (Personal communication.) Since doing this, they see pneumonic emboli following such operations less frequently than formerly. As Albanus, quoted above, states, sepsis is naturally to be thought of as a factor in these cases. Hence one is not surprised at the remark of Sonnenburg, that 5 per cent. of all appendix operations are attended with thrombosis somewhere in the vicinity.

The reason for the greater number of cases given in the literature as showing thrombi originating from the femoral, epigastric and pelvic veins, as far as the surgeon is concerned, is due to the fact that pelvic and abdominal operations are much more frequently performed than operations in other parts of the body. Operations elsewhere, where veins are subject to trauma or infection are as apt to be followed by thrombosis and subsequent pulmonary embolism as they are in the before mentioned situations. This may be illustrated by the following case.

('05.7) Male, age 70 years. *Larynx removed for carcinoma. Eight days later sudden death.* Autopsy four hours after death showed the trunk of the pulmonary artery occluded by partially organized blood clot, 1.5 cm. in diameter. The clot extended into both the main divisions of the artery. The lungs were œdematous and congested. The right heart was distended and filled with blood. The neck was swollen and œdematous. Operative wound at site of larynx showed some superficial necrosis with healthy appearing granulation tissue below. On the right side, the internal jugular vein was distended to a diameter of 3 cm. and was occluded by a solid grayish granular thrombus for a distance of 8 cm. The neighboring tissue was stained by blood pigment. Anatomical diagnosis. Thrombosis of internal jugular vein with resulting occluding embolism of pulmonary artery.

The frequency of pulmonary embolism (including the cases of embolism of the smaller branches of the pulmonary artery that give rise to little or no permanent after-effect) is much higher than is usually supposed in both surgical and non-surgical diseases. Virchow found that in ten cases of thrombosis of the veins of the lower extremity, six were followed by pulmonary embolism. Albanus found that 43 per cent. of the cases showing thrombosis after laparotomies were followed by pulmonary embolism. (This amounted to only 2 per cent. of the operated cases since only 53 cases of thrombosis were found in 1140 laparotomies; 23 of which were followed by pulmonary embolism.) On the contrary Quenstedt and

also Leichtenstern found pulmonary embolism in 20 per cent. of their cases of thrombosis. Opposed to this again is the record of Lubarsch, who in 584 cases of thrombosis found pulmonary embolism 347 times, *i.e.*, in 59.1 per cent. of his cases.

In none of these instances is it stated how frequently the embolus was of sufficient size to cause death by blocking the pulmonary artery. These cases are not rare and from those that have been reported a few may be cited.

Welch has collected twenty-three cases of venous thrombosis in which there were at least 3 deaths due to pulmonary embolism consecutive to the thrombus. Mynter mentions a case in which sudden death was probably due to pulmonary embolism following thrombosis of the femoral vein in appendicitis. Robinson describes a typical death from pulmonary embolism seventeen days after hysterectomy. Koenig reports a case where the patient died from pulmonary embolism although the thrombosed vein (saphenous) had been removed for the purpose of avoiding just such an untoward outcome. In this instance the clot probably extended into the femoral vein and was therefore not totally extirpated.

From the cases that have occurred in the practice of one of us and from cases that came to autopsy at the Boston City Hospital, most of them during the service of Dr. Thompson, and for which we wish to express our indebtedness to Dr. F. B. Mallory, we append the following list.

1. *Carcinoma of Larynx*.—(Autopsy, Thompson.) Death instantaneous eight days after operation. Occlusion of main stem of pulmonary artery by embolus. Thrombosis of internal jugular vein.

2. *Myoma of Uterus*.—(Autopsy, Thompson.) Death sudden thirteen days after operation. Occlusion of both branches and trunk of pulmonary artery by embolus. Thrombosis of ovarian veins.

3. *Compound Fracture of Leg*.—(Autopsy, Thompson.) Death thirty minutes, eight days after injury. Main trunk and right pulmonary blocked by embolus. Thrombosis right heart. Culture from heart's blood sterile.

4. *Contusion of Knee*.—(Autopsy, C. W. Duval.) Time in dying thirty minutes. Embolus of trunk and branches of pulmonary artery. Thrombosis of right femoral.

5. *Appendectomy*.—(Autopsy, Dr. Brinkerhoff.) Death in five minutes, eight days after operation. Complete embolism of main trunk of pulmonary artery. Abscess at appendix site.

6. *Gangrene of Heel; Myocarditis; Alcoholic Neuritis*.—(Autopsy, Dr. S. B. Wollbach.) Eleven hours in dying. Embolism of branches of pulmonary artery except branch to upper lobe of right lung. Thrombosis of femoral, external pudic and profunda. Culture from heart's blood sterile.

7. *Appendectomy*.—(Autopsy, Dr. Marchildon.) Died in ten minutes, fifteen days after operation. Occlusion of both branches of pulmonary artery by embolus. Thrombus not found.

8. *Uterine Myomata and Gall-stone Disease*.—(Autopsy, Dr. Tiedeman.) Six days after operation collapse with recovery: four days later another attack of similar nature, and in two more days (two weeks after the operation) pulmonary embolism with death in thirty minutes.

9. *Clinical Diagnosis Hemorrhagic Pleurisy*.—(Autopsy, Dr. Brinkerhoff.) Autopsy findings scant save for thrombosis of left pulmonary and popliteal arteries. Embolism of right pulmonary. Death sudden. Culture from thrombus show colon-like bacillus.

10. *Tuberculosis of Lungs*.—(Autopsy, Thompson.) Embolism of left pulmonary artery. Two hours in dying. Cultures from heart's blood show streptococcus.

11. *Bronchopneumonia and Acute Otitis Media*.—(Autopsy, Thompson.) Embolism both branches of pulmonary artery. Five hours in dying. Culture from heart's blood sterile. Middle ear streptococcus and staphylococcus aureus.

12. *Typhoid Fever*.—(Autopsy, Dr. E. E. Southard.) Complete blocking of pulmonary artery by embolus. Death in fifteen minutes. Thrombosis of right common and internal iliacs.

13. *Myocarditis; Aortic Endocarditis; Hypertrophy and Dilatation of Heart*.—(Autopsy, Thompson.) Embolism of branches of pulmonary artery to lower lobes only, with hemorrhagic infarction. Twelve hours in dying. Thrombosis of right heart. (Death in this case due to weak heart as embolism not sufficient to cause death under ordinary conditions.)

14. Similar to last case. *Myocarditis; Hypertrophy and Dila-*

tation of Heart.—(Autopsy, Dr. H. A. Christian.) Embolism of branches of pulmonary artery with hemorrhagic infarctions, both lower lobes and upper left lobe of lung. Death sudden. Thrombosis of right heart.

15. *Umbilical Hernia and Talma Operation for Cirrhosis of Liver.*—This patient experienced all the typical symptoms of pulmonary embolism with sudden death as did those whose records succeed this one except two to be mentioned later. He was operated upon for a large umbilical hernia and at the same time the Talma operation for cirrhosis of the liver was performed. Eleven days after the operation he suddenly became breathless, cyanosed, and in ten minutes was dead. No autopsy could be obtained in this or the succeeding cases, hence they are submitted not as proven instances of pulmonary embolism but as suggestive cases in surgical practice in which a better explanation for death cannot be given.

16. *Hysterectomy for Carcinoma.*—A lady fifty-six years of age was operated upon by the Wertheim method for cancer of the uterus. No unusual features marked her convalescence. She was up on time and when preparing to go home four weeks after the procedure, suddenly dropped to the floor while crossing the room, gasped for breath and was dead in thirty minutes.

17. *Resection of Stomach for Carcinoma.*—A man sixty-eight years of age suffering from cancer of the stomach underwent a resection without shock or subsequent ill effects for three days. He was sitting up in bed talking to his nurse, having taken liquid nourishment and being entirely without abdominal symptoms, when suddenly he became unable to get his breath, as the nurse related, dropped back deeply cyanosed and died a few minutes later.

18. *Hysterectomy for Carcinoma.*—Another Wertheim operation for cancer of the uterus done on a lady forty-four years of age resulted in sudden death in very much the same way. Ten days after the operation she was sitting up in bed having just partaken of a light lunch, when suddenly she began to breathe with great difficulty, extremities became cold, every evidence of extreme shock appeared and in eleven hours she was dead.

19. *Umbilical Hernia.*—An operation for umbilical hernia on a lady fifty-two years of age was attended by a somewhat similar set of symptoms but resulted favorably. Eight days after the

Mayo overlapping operation there was a sudden onset of the manifestations just related. However, under stimulating treatment she gradually began to breathe more easily and in twenty-four hours was considered out of immediate danger. She gradually improved, left the hospital a month later and has remained well ever since.

20. *Appendectomy*.—A man thirty-eight years of age was operated upon for appendicitis in the interval. The procedure was very difficult and consisted of the removal of a stiff, tightly adherent appendix. His recovery was devoid of any untoward incident up to the ninth day, when being allowed to get up for the first time he suddenly became intensely cyanotic, breathless, unconscious and died in a very few minutes.

21. *Intestinal Resection* with Murphy button anastomosis was done on a man fifty-four years of age and two days later, while he was normal, apparently comfortable and conversing with one of us, he suddenly gasped for breath, became blue, unconscious and was dead within five minutes. This case was clearly one of some form of suffocation. However, there was no obstruction in the air-passage, since a knife that happened to be handy was plunged into his trachea and one lung inflated through catheter, hence this suffocation can only be regarded as due to the sudden interruption of the oxygen carrying blood stream.

22. *Varicose Veins of Leg*.—A lady forty-seven years of age was operated upon for varicose veins on the lower leg. A combined Mayo-Schede operation was performed. The same evening she became suddenly cyanotic, complained of shortness of breath, pain and compression in the chest; intense anxiety was present; extremities became cold, but the symptoms rather rapidly disappeared and as yet no further danger of this kind has been encountered. She is, however, in the hospital at the time of writing.

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It may be of value in the sixteen surgical cases to note the interval of time that elapsed after operation or injury before the onset of pulmonary symptoms. In two of these this feature is not noted in the records, hence but fourteen are left for our consideration. In these cases this period was as follows:

One, one day; one, two days; one, three days; one, six

days; four, eight days; two, nine days; one, eleven days; one, thirteen days; one, fifteen days; one, twenty-eight days.

An average shows that a little less than seven days intervened as a rule between the time of operation or injury and the lodgment of the blood clot in the pulmonary artery. It should be noted that in those cases where embolism occurred a few days after operation that the condition was such that thrombosis may have been present some time before operation.

Twenty of the twenty-two cases cited resulted fatally. In this connection it is interesting to note the time intervening between the onset of symptoms and the occurrence of death. These are given as found in the hospital records:

Three, suddenly or instantly; one, almost instantly; one, few minutes; three, five minutes; two, ten minutes; one, fifteen minutes; four, thirty minutes; one, two hours; one, five hours; one, eleven hours; two, twelve hours.

As far as the symptoms of thrombosis preceding pulmonary embolism are concerned, Lotheisen has very properly remarked that they very often fail entirely. However, Schlachter has made some very interesting observations which may be of value in this connection. He had the opportunity of studying seven cases at Zurich and noted that the temperature remained normal in all of them while the pulse gradually rose in a step-like (*stapelfoermig*) manner, until the lung symptoms became manifest. He regards this change in the pulse as indicative of thrombus formation.

The symptoms of pulmonary embolism cannot fail to be burned into the memory of one who has ever seen a patient die as a result of this accident. The seemingly normal individual suddenly becomes breathless, cyanotic, anxious, restless, complains of pain and oppression in the chest, the pupils grow wide, cold sweat pours and unconsciousness quickly supervenes. The pulse in many instances becomes rapid and irregular to the point where it cannot be counted at all. In one case which we have mentioned we had apparent complete blocking of the main trunk where symptoms of complete suffocation suddenly appeared, the pulse, as might be expected when air is instantly

cut off, became slower and less compressible. The symptoms in general are analogous to those which are seen when one of the main branches of the pulmonary artery is ligated in a dog. The rapid over-distention of the right ventricle which ensues is accompanied by a lowering of arterial blood pressure and a tremendous rise of venous pressure. Whether cyanosis, dyspnoea and failing pulse are referable to asphyxia or cerebral anæmia or interference with the coronary circulation or to all three together is, according to Welch, neither easy nor important to determine.

Unfortunately the treatment of such conditions must be largely of a preventive nature. A very strong heart may tide over an individual in whom only one branch of the artery is occluded and consequently the opinion is general that every heart should be aided as much as possible by stimulation. However, not much is to be expected in most instances. In order to prevent just such accidents, Mueller cites cases in which he ligated quite a number of varicose veins in the lower extremity, while Kramer split varicose saphenous veins in fifty instances and evacuated thrombi to prevent pulmonary embolism, as well as the local effects of the disease. He was successful in every instance. Becker advises the removal of the saphenous vein when the thrombus has not extended into the femoral vein. It has recently been suggested that the pulmonary artery may be opened and the embolus removed.

Our own suggestion prompted by more than one of the cases above recorded relates to varicose veins in the vicinity of abdominal tumors. Not infrequently are these seen in the female pelvis, especially in connection with myomata of the uterus. They should if possible be extirpated with the growth, or at least ligated as far out as possible toward the pelvis wall, to avoid the likelihood of thrombosis (if they are left behind) with a subsequent fatal accident of the most distressing nature.

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